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Original Research

Effects of Ankle Compression Garments on Fatigue and Single-Leg Balance in Collegiate Basketball Players

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ABSTRACT

International Journal of Exercise Science 17(1): 611-622, 2024. Basketball players are prone to ankle injuries. It is unclear if wearing ankle compression garments (CGs) can enhance balance control and time to fatigue in those athletes. The purpose of this study was to examine the impact of ankle CGs on both time to fatigue and single-leg balance. Sixteen Division II (D2) collegiate basketball players participated in the study. The Cumberland Ankle Instability Tool (CAIT) was used to assess ankle stability. Fatigue was induced through deficit heel raises, and single-leg balance was assessed with the Athletic Single Leg Stability Test (ASLST) of the Biodex Balance System. Ten out of 16 (62.5%) basketball players were classified as having chronic ankle instability (CAI). Wearing CGs did not significantly prolong the time to fatigue (P = .774), and participants with CAI and without CAI had a similar time to fatigue (P = .958). In addition, wearing CGs significantly worsened single-leg balance before fatigue (P = .021), but enhanced balance control after fatigue (P = .027). Results indicate a strong prevalence of CAI in collegiate basketball players, and wearing CGs may not be able to enhance single-leg balance before fatigue. Although participants who wore CGs did not significantly increase their time to fatigue, their single-leg balance significantly improved after fatigue. This finding suggests wearing ankle CGs may have the potential to remediate the impact of fatigue on balance control. Future studies with a larger sample size are needed to further examine the impact of wearing ankle CGs on fatigue and single-leg balance.

KEY WORDS: Chronic ankle instability, balance, compression garment, basketball

INTRODUCTION

One of the most prevalent musculoskeletal injuries that can occur in the general population is the lateral ankle sprain, which is even more prevalent in those participating in sports (26). The term sprain refers to an injury, which indicates if the structural integrity of the ligament has been compromised in function and stability (14). The ankle ligament most commonly compromised during a sprain is the anterior talofibular ligament. An estimated 2 million ankle injuries occur in a year in the United States alone, accounting for 20% of all sports-related injuries (17). Prior ankle injuries or limited joint flexibility are also significant predictors for future lateral ankle sprains, which means most of those affected by ankle sprains will most likely have recurrent injuries (17). Moreover, basketball players have one of the highest incidences of sports-related injuries, and 22.6% of the injuries are ankle ligament sprains (25). Lateral ankle sprains are typically due to a combination of fast ankle plantar flexion and inversion while performing a single-limb landing on an uneven surface (14). However, other factors such as fatigue can also increase the chance of ankle injuries (28).

Fatigue is defined as the body's inability to supply sufficient energy to the muscles to meet the muscle's energy demand (16). Basketball is commonly described as a moderate-to-long duration sport with the players continuously using movements like sprinting, cutting, and jumping throughout a game (6). Basketball players often have a large muscle mass, which makes them more prone to fatigue in comparison to smaller or leaner athletes (3). Thus, fatigue of lower extremity muscles could occur relatively quickly and increase the prevalence of ankle injuries. Fatigue of dynamic ankle stabilizers (such as ankle dorsiflexors and evertors) can place the ankle in a vulnerable position for lateral ankle sprains, and ultimately impact an athlete's performance (16).

Sensory input from the skin, joint capsule, ligaments, and muscle spindles, contributes to the maintenance of postural control (11). In addition to proprioceptors, balance control relies on muscle strength, endurance, and experience (15). Studies have shown that muscle spindles play a significant role in providing proprioceptive feedback for joint position (position sense) and movement (movement sense), and muscle fatigue can impact muscle spindle function and compromise proprioceptive feedback (11). If a basketball player's awareness of his/her ankle position and movement is hampered, the player would be less efficient in positioning the ankle in a more stable position during landing or engaging proper muscle force to counter perturbations.

Compression garments (CGs) are widely used in athletic performance, from recreational athletes to professional levels. CGs can differ significantly in the amount of compression, range from single-joint to full-body coverage, and are made with a variety of materials in numerous shapes and sizes. Studies have shown that CGs can enhance athletic performance (20), reduce sports-related risk of injury through improving body mechanics (24, 33), and improve recovery time (6). Wearing ankle CGs could enhance balance with improved proprioceptive inputs, decrease fatigue's negative effects on neuromuscular control, and provide additional support to the ankle joint (8, 23). Because basketball players have a high prevalence of ankle injuries, the purpose of this study was to examine the impact of ankle compression garments on both time to fatigue and single-leg balance control in Division II (D2) collegiate basketball players with and without chronic ankle instability. Our hypothesis posited that the utilization of a compression garment around the ankle joint would lead to two primary outcomes: Firstly, an increase in the time to fatigue; and secondly, a reduction in the adverse effects of fatigue on single-limb balance control among collegiate basketball players.

METHODS

Participants

This is an explanatory research with the one-way repeated measures design. It used convenience sampling. Sixteen (8 male, 8 female) D2 collegiate basketball players (aged 19-23 years) from Angelo State University participated in the study. Participants were included in the study if they 1) were a collegiate basketball player at Angelo State University, 2) were able to stand and balance on the dominant leg for a minimum of 1 minute without pain or discomfort, and 3) were able to perform 10 standing calf raises without pain or discomfort. The Physical Activity Readiness Questionnaire (PAR-Q+) form was used to screen participants' ability to participate in the fatigue protocol. If participants answered yes to any of the seven questions on the first page, they were excluded from the study. Participants were also excluded from the study if they failed the screening test. All participants signed a consent form approved by the Institutional Review Board of Angelo State University. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (21).

Protocol

Only the dominant leg of the participants was examined in this study. The Cumberland Ankle Instability Tool (CAIT) was used to examine subjective ankle instability. It is a simple questionnaire consisting of nine questions. The questions allow the participants to give insight into how they perceive their ankle stability during functional activities. A total score of 25 or less indicates functional ankle instability (19). The scoring for the CAIT ranges from 0 (worst) to 30 (best), and it has a minimum clinically important difference of 3.05 (31). This CAIT also has a sensitivity of 0.966 and a specificity of 0.868 (30). The Biodex Balance System (Shirley, New York) is an apparatus that objectively measures static (such as the Fall Risk test) and dynamic (such as the Limits of Stability test) balance control by implementing a multi-axial testing platform that will abruptly change positions by varying degrees. The Overall Stability Index (OSI) represents standard deviations assessing changes in the horizontal plane in both anterior-posterior and medial-lateral directions (2). The index allows for a quantitative comparison of balance performance between different individuals or between pre- and post-intervention assessments**.** The Athletic Single-leg Stance Test (ASLST) of the Biodex Balance System (BBS) was used in this study to assess static single-leg balance. The ASLST platform can be set to different levels of stability with a maximal 20-degree surface tilt, and the platform has good test-retest reliability (ICC: 0.77) (1). The ankle compression garments (CG) used in this study are commercially ready and can be found at many large retailers. The top of the garment stops just below the calf muscle, while the bottom of the garment stops at the arch of the foot leaving a hole for the heel to fit. On the first day of testing, participants provided their shoe size and were given a corresponding CG for the ankle of their dominant leg. The ankle CG provided a sense of compression without restricting their mobility at the ankle or restricting circulation.

All testing was performed at the Motor Control Laboratory of the Physical Therapy Department. The flowchart of the study is depicted in Figure 1. Before testing, each participant was asked to complete a screening process to ensure that all individuals met the inclusion criteria prior to participation. During the screening, participants had to show that they were able to 1) stand and balance on the dominant leg for a minimum of 1 minute without pain or discomfort and 2) successfully perform 10 standing calf raises without pain or discomfort. Once the participant was cleared for the study, they filled out the CAIT questionnaire for the dominant leg and proceeded to official testing.

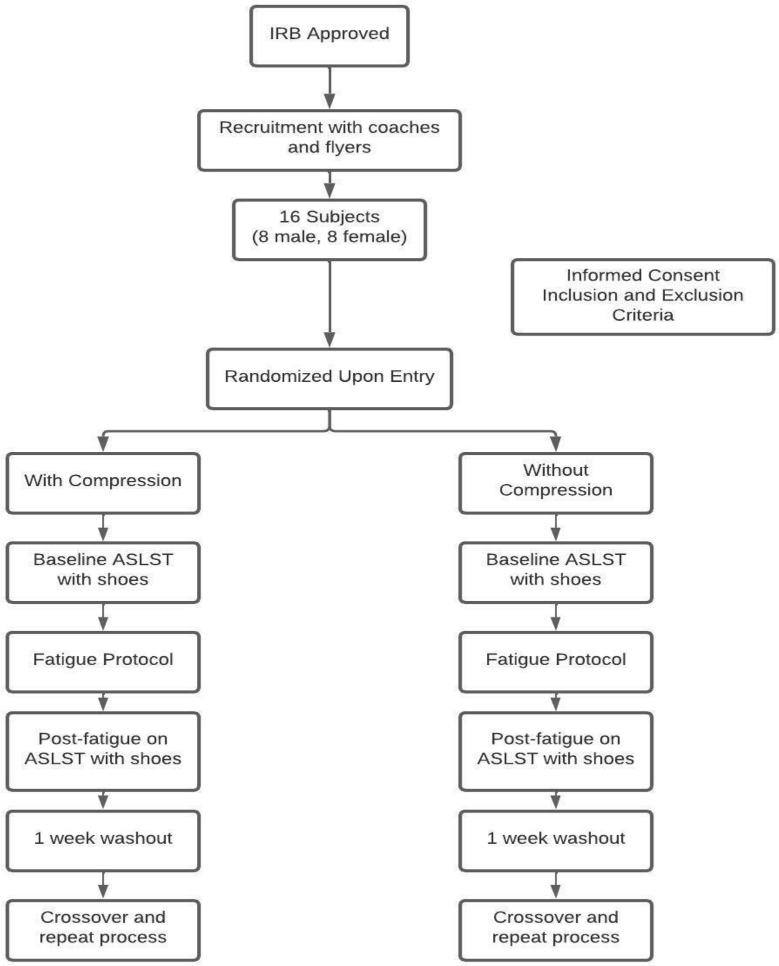

Figure 1. Outlines the experimental procedures from IRB approval to data collection. IRB = Institutional Review Board; ASLST = Athletic Single-limb Stance Test

Participants were examined on two separate occasions, with a one-week break between sessions (washout period) to reduce carryover factors such as the practice effect and muscle soreness after the first testing. Participants were randomly assigned to 2 conditions: wearing just their socks for the no CG condition or wearing an ankle CG over the existing sock for the dominant leg. After the first visit, they returned to perform the second condition after a week. Participants completed a baseline (pre-fatigue) ASLST, fatigue protocol, and a post-fatigue ASLST during each visit.

The fatigue protocol (4) was performed on top of a 6-inch step, where the participant performed deficit calf raises with both legs. A chair was placed in front of the step to give the participants a place to rest their hands and maintain steadiness while performing deficit calf raises. A metronome was set to 30 beats/min to provide the participant with a cadence to follow, and encouragement was provided to keep the participant motivated and to perform as many calf raises as possible. The fatigue protocol was ended when participants 1) were too fatigued to continue or 2) failed to adhere to the metronome cadence for two consecutive beats. The 20-point Borg Rating of Perceived Exertion Scale (RPE) was used to indicate fatigue status (4). The scale ranges from 6 (no exertion, sitting and resting) to 20 (maximal exertion), and the participants needed to reach 17 (very hard) or above to indicate reaching the fatigue state. Time to fatigue was measured during each session, and the ASLST was performed immediately after the participant reached fatigue.

For the ASLST, participants were asked to maintain balance with a single-leg stance. All participants were without footwear on the Biodex Balance System (BBS). The participant's foot was placed at the appropriate level based on the participant's height, determined by the BBS operations manual. The participants were asked to keep their foot position consistent throughout the testing. During testing, participants were instructed to maintain slight knee flexion, look straight ahead, have their arms in a neutral position, and only grab the rails if they fall. For safety purposes, the researcher stood behind the participant. The ASLST was set at the default level (dynamic level four with moderate balance control difficulty) for all the testing. This moderate level was chosen to be challenging enough for the athletes, but not too challenging for the participants in the fatigued condition. For practice, the participant performed three 20-second trials with a 10-second rest in between while receiving extrinsic visual feedback from the monitor. The monitor showed the participant's center of gravity as a dot on the grid and a line tracking the path of their center of gravity throughout the trials. The official testing also included three 20-second trials with a 10-second rest in between while receiving extrinsic visual feedback from the monitor. Immediately after completing the fatigue protocol, participants went directly to the official testing without practice to ensure the testers were able to capture the fatigue effect on the participant's balance control before recovery was made.

Statistical Analysis

Statistical analyses were performed using IBM SPSS version 26 (IBM Corp, Armonk NY). The 2-way mixed ANOVA was used to examine the effects of two independent variables (presence of chronic ankle instability and wearing ankle compression garments) on two dependent variables (time to fatigue and single-leg balance control) measured under different conditions (pre-fatigue and post-fatigue). Additionally, a paired sample *t*-test was used to analyze the effect of fatigue on single-leg balance**.** The significance level (*P* values) was set at .05 for all comparisons.

Figure 2. The Athletic Single Limb Stance Test on the Biodex Balance System. The participants were able to utilize visual feedback from the monitor in order to maintain their Center of Gravity on the platform.

Figure 3. The fatigue protocol. The participants were allowed to touch the support to gain proprioceptive feedback for balance control. A metronome provided a standardized cadence for the heel raises. The ankle compression garment is pictured here on the participant's right ankle.

RESULTS

Based on the Cumberland Ankle Instability Tool (CAIT), 10 out of 16 (62.5%) basketball players were classified as having CAI. Although the average time to fatigue increased from 2.868 minutes (no CGs) to 3.148 minutes (with CGs), results of the 2-way mixed ANOVA showed wearing CGs did not have a significant impact on time to fatigue ($F = .086$, $P = .774$, $\eta_p^2 = .006$). Participants with CAI and without CAI had a similar time to fatigue ($F = .003$, $P = .958$, $\eta_p^2 = .000$) (Figure 4). The interaction effect of CGs and ankle stability status was not statistically significant ($F = 2.261$, $P = .155$, $\eta_p^2 = .139$). Prior to fatigue, participants exhibited significantly better single-leg balance without CGs (mean Stability Index: 1.500) than with CGs (mean Stability Index: 2.013) ($F = 6.811$, $P = .021$). The Partial Eta Squared ($\eta_p^2 = .327$) indicates a large effect size ($\eta_p^2 \geq .14$). However, neither the ankle condition ($F = 1.649$, $P = .220$, $\eta_p^2 = .105$) nor the interaction ($F = .500$, $P = .491$, $\eta_p^2 = .034$) had a significant impact on single-leg balance control (Figure 5). After fatigue, CGs condition ($F = .401$, $P = .537$, $\eta_p^2 = .028$), ankle stability status ($F = .436$, $P = .520$, $\eta_p^2 = .030$), and their interaction ($F = .570$, $P = .463$, $\eta_p^2 = .039$) did not have a significant impact on single-leg balance control (Figure 6).

The paired sample *t*-test shows fatigue had a significant impact on single-leg balance when participants wore CGs [$t(15) = 2.443$, $P = .027$]. Surprisingly, participants' mean Stability Index improved from 2.013 (pre-fatigue) to 1.563 (post-fatigue). On the other hand, fatigue did not significantly impact single-leg balance when participants did not wear CGs [$t(15) = -1.345$, $P = .196$]. Participants' single-leg balance control slightly worsened from 1.500 (pre-fatigue) to 1.675 (post-fatigue).

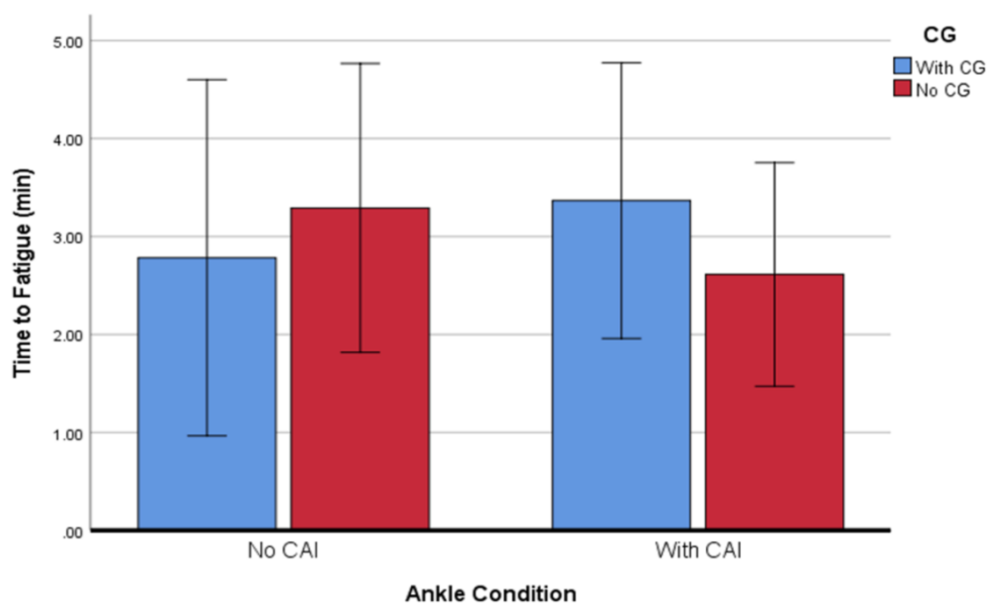

Figure 4. Time to fatigue (min) is demonstrated in those with and without CAI. CG status is noted by the bar graph colors (red = no CG). The error bars exemplify 1 standard deviation. CAI = Chronic Ankle Instability; CG = Compression Garment

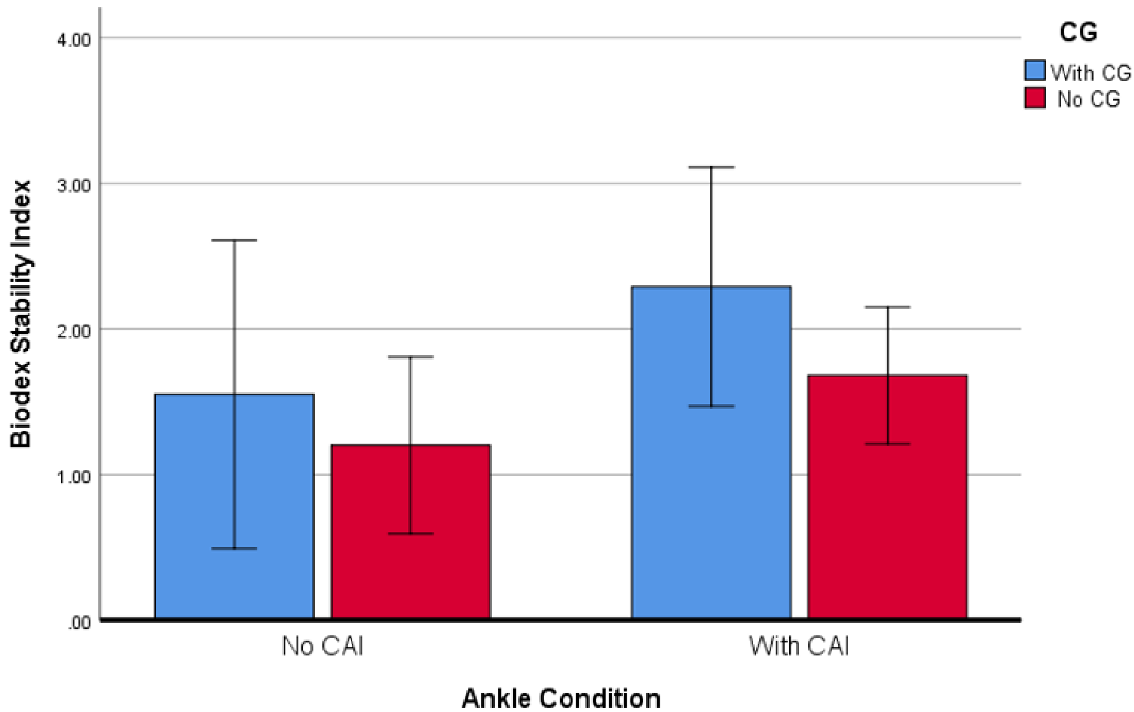

Figure 5. Pre-fatigue Biodex stability scores are denoted on the y-axis, while CAI conditions are noted on the x-axis. CG status is determined by the color of the bar (red = no CG). The error bars represent 1 standard deviation. CAI = Chronic Ankle Instability; CG = Compression Garment

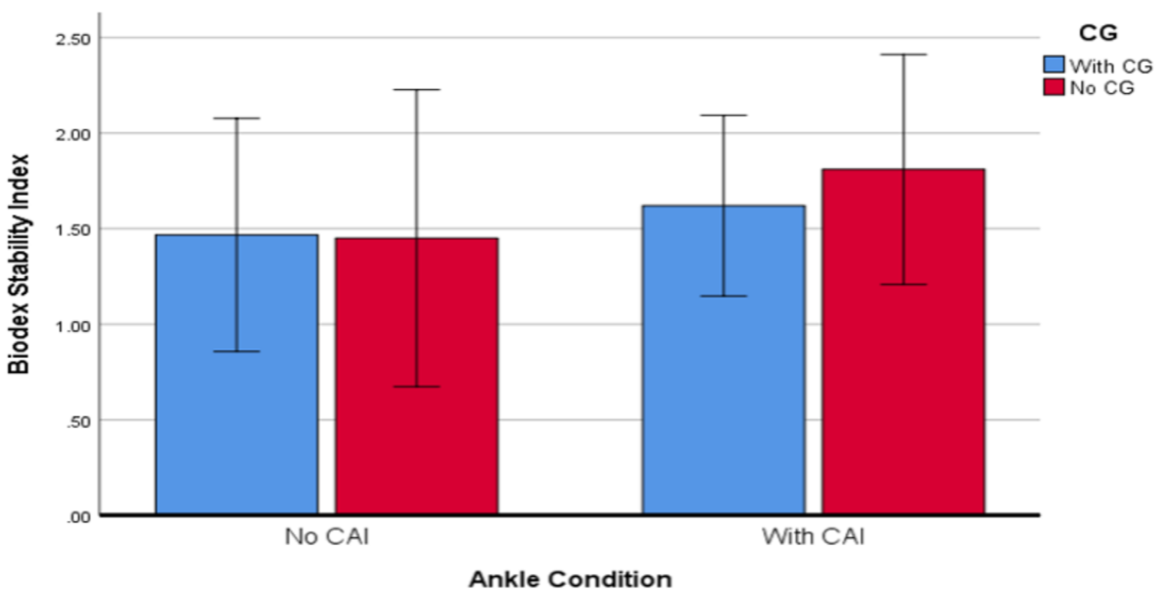

Figure 6. Post-fatigue Biodex Stability scores are denoted on the y-axis, with the x-axis representing the CAI condition. CG status is determined by the color of the bar graph (red = no CG). The error bars represent 1 standard deviation. CAI = Chronic Ankle Instability; CG = Compression Garment

DISCUSSION

Results of the present study show more than half of the participants were classified as having CAI. This finding agrees with the literature which indicates a high prevalence of ankle injuries in athletes, especially in basketball players. Waterman et al. reported that basketball has a much higher incidence of ankle sprains (41.1%) compared to football (9.3%) and soccer (7.9%), which make up the majority of sport-related ankle sprains (27). In addition, Lin et al. examined 391 Taiwanese collegiate and semi-professional basketball players and found 26% of them had unilateral CAI and 50% had bilateral CAI (18). After the initial injury, due to compromised static and/or dynamic stabilizers of the ankle joint, recurrent injuries can often lead to CAI and further compromise sports performance. Clinicians who work with basketball players should be aware of the high prevalence of ankle injuries and incorporate proper training and rehabilitation protocols for these athletes.

Results show wearing ankle CGs only slightly (not statistically significantly) increases the time to fatigue. This finding does not support the hypothesis (an increase in the time to fatigue with CGs**)**. It is also not consistent with the study of Hong et al., who reported wearing lower body CGs improved muscle performance in a vertical jump fatigue protocol, reduced decrement in post-fatigue proprioception (medial-lateral displacement of the center of pressure), and improved recovery after fatigue when compared to wearing non-compressive sports pants (12). One possible explanation for the difference between the two studies is that participants of Hong's study wore full-length hip-to-above-ankle CGs that covered all major muscle groups and joints of the lower extremities. Therefore, the benefits of wearing full-length CGs could be larger than wearing ankle cuffs. Another possible explanation for the small fatigue time increment could be the limited sample size. Future studies with a larger sample size will be beneficial to examine further the impact of wearing ankle CGs on the time to fatigue. In addition, the impact of wearing CGs on fatigue duration was the same for those with and without CAI. One possible explanation is that the current fatigue protocol did not stress the anatomical structures that were compromised with CAI. For participants with CAI, their lateral ligament integrity and fibularis longus/brevis strength could be compromised. Those deficits may not be targeted and wearing ankle CGs may not provide additional benefits with the current fatigue protocol. Future studies with a fatigue protocol that stresses those compromised tissues with CAI would be beneficial.

When assessing the ASLST prior to fatigue, it was found that single-leg balance without the CGs was significantly better than with the CGs. One possible explanation is that tightly fitted ankle CGs may have restricted the ankle range of motion and therefore interfered with single-leg balance control. This possibility could be supported by Hall et al. who theorized that prophylactic ankle support reduces injuries by decreasing the available range of motion (ROM) in the joint (10). Specifically, reducing ankle dorsiflexion would make the ankle joint less stable, therefore impacting balance control. When assessing the ASLST post-fatigue, it was found that the ankle condition, CG condition, or their interaction did not significantly affect balance control. Potentially, this could be due to the participants not reaching a true fatigue state (29) or the participants being copers who are able to perform at high levels despite previous injury (10). Future studies with a larger sample size will be beneficial to examine those effects further.

The paired *t*-test comparing pre- and post-fatigue balance with CGs shows that fatigue significantly affected single-leg balance when participants wore the CGs. Surprisingly, participants' mean Stability Index improved from 2.013 (pre-fatigue) to 1.563 (post-fatigue). One possible explanation is the motor learning effect. Although there was a one-week wash-out period between testing, it is still possible that some motor learning/acclimation effects carried over to improve the performance after fatigue. With the CGs, the additional somatosensory information could further amplify the motor learning effect, therefore masking the negative impact of fatigue. Lastly, when comparing pre-fatigue and post-fatigue balance without CGs, it was noted that fatigue did not significantly impact single-leg balance. However, participants' scores slightly worsened in the post-fatigue condition. This finding is supported by the negative impact fatigue can have on muscle spindle sensitivity. Muscle spindles are the primary contributors to proprioception (11). Thus, a decrease in proprioception and balance control after fatigue could be a reasonable expectation.

The main limitation of this study is the small sample size. Future studies with a larger sample size will be beneficial to enhance the power of this study (9). With a limited number of basketball players in each university, a multi-institutional collaboration will be beneficial to have more participants, maybe even looking into the differences between genders. Additionally, the RPE was used to obtain a subjective measurement of fatigue levels. It will be beneficial for future studies to examine the effects of fatigue utilizing a more objective fatigue protocol, such as tracking the participant's heart rate instead of RPE to indicate reaching the fatigue state.

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